California Central Valley Dairy Waste and Nutrient Management

Annual Nutrient Application Tracking and Reporting Computations Documentation

Information and Computations

Software format, computation methods, and content are a reflection of Central California regulatory compliance goals [California Regional Water Quality Control Board Central Valley Region, Order No. R5-2007-0035, Waste Discharge Requirements General Order For Existing Milk Cow Dairies (RB5GO)]. This document contains support materials for the Annual Nutrient Application Tracking and Reporting (ANATR) module, a component of a larger internet based dairy compliance software application specific to California's Central Valley. The ANATR is intended to provide a detailed assessment of a dairy facility's nutrient generation, applications to crops, imports, exports (manifested), crop harvest, laboratory analytical data tabulation and standardized reporting in accordance with the RB5GO. Computations utilized in the ANATR module are approximations from process based assessment approaches to facility specific nutrient generation of manure and process waste water, with subsequent land application, import, export and management practices in a relatively open biological system. Completion of an ANATR will provide owners and operators with a more detailed perspective of individual dairy facility compliance status in accordance with current regulatory requirements. Computational methods utilized are conservative. This software relies on user entered information and employs computational methods in accordance with generally accepted principals and practices at the time of release and is subject to change. See Release Notes for up to date information on software modifications. This software was developed with a grant from the California State Water Resources Control Board, Agreement Number 10-100-150.

Reporting Period

Annual reports are identified by the user through a description and reporting period process. The user defined report description does not appear on printed Annual Reports. The reporting period will appear on the printed report and will typically be a calendar year starting January 1 and ending December 31 (365 days).

Owners/Operators

The user must enter, record, and report all persons who owned and/or operated the dairy within the reporting period.

Herd Information

The user must define, record, and report the herd size considering the most common configuration during the reporting period, entering the numbers of animals at the facility, whether in open confinement or under roof. The user must enter the overall maximum herd and maturity stage

populations at the facility during the reporting period to estimate nutrient excretions during the reporting period. Average milk production and predominant animal breed name is required.

Herd Computations

All manure nutrient excretion daily subtotals are stored, summed then multiplied by the user defined reporting period expressed in days to obtain annual totals for reporting outputs, quantifying nitrogen, phosphorus, potassium, and salt generated. Consideration of appropriate and defensible selections by the user is imperative to properly estimate realistic nutrient values for reporting purposes.

Herd Manure Nitrogen, Phosphorus, Potassium and Salt Excretion

Estimated nitrogen content of manure excreted by the herd is based upon March 2005, American Society of Agricultural and Biological Engineers (ASABE, formerly ASAE) 384.2, Section 5.3.7, Equation 16, page 8, for milk cows, and Table1.b, Section 3, page 2 values for dry cows, heifers, and calves. Estimated phosphorus content of manure excreted by the herd is based upon March 2005, American Society of Agricultural and Biological Engineers (ASABE, formerly ASAE) 384.2, Section 5.3.10, Equation 22, page 8 for milk cows, and Table1.b, Section 3, page 2 values for dry cows, heifers, and calves. Estimated potassium content of manure excreted by the herd is based upon March 2005, American Society of Agricultural and Biological Engineers (ASABE, formerly ASAE) 384.2, Section 5.3.13, Equation 26, page 8, for milk cows, and Table1.b, Section 3, page 2 values for dry cows. Potassium excretion estimates for heifers and calves are excluded at this time. Table value nutrient excretion rates from ASAE 384.2 and other sources are listed in this document in the Constants and Conversion Factors appendix. Constants and standard conversion factors are recognized as all caps terms in the equations below (ex; -*"KG_PER_LB"* and *"PHOSPHORUS_EXCRETION.DRY_COW"*). Inorganic salt excretion from milk cows is estimated at 1.29 lbs/cow/day, and dry cows at 0.63 lbs/cow/day from the University of California Committee of Experts (UCCE) report entitled Managing Dairy Manure in the Central Valley of California, University of California, Division of Agriculture and Natural Resources, Committee of Experts on Dairy Manure Management, June 2005 revision, page 10. Salt excretion estimates for heifers and calves are excluded at this time. Herd manure mass, volume, and nutrient content (nitrogen, phosphorus, potassium, and salt) as residual in storage is not estimated at this time.

It is important to note that manure excretion is directly related to herd drinking water and feed composition, quality and quantity ingested, along with other important environmental conditions. Expected changes in diets and environmental conditions among other factors can create variable manure quantity and component content. These variables further complicate collection efficiencies, separation processes, liquid manure and solids accumulation estimates in storage systems (i.e., particle buoyancy, suspension, and precipitation), subsequent nutrient application to land, and nutrient availability to crops through numerous bio-chemical and physical/mechanical processes including nitrogen mineralization. As manure and bedding solids move and cycle through the dairy facility and manure management systems, particle sizes and distribution may change along with resultant relative densities, volumes, and nutrient composition, affecting nutrient budget/balance estimates.

Herd; Manure Generated, Nitrogen, Phosphorus, Potassium and Salt Excretion Computations

Manure Generated

```
' Milk production into kilograms.
milk = AvgMilkProduction * KG_PER_LB

' Manure excreted per day per maturity stage expressed in pounds.
HerdManurePerDayMilkCow =
       ((milk * 0.647) + 43.212) * LBS_PER_KG * MaxMilkCowCount
HerdManurePerDayDryCow =
       (((DryCowAvgWeight / LBS_PER_KG) * 0.022) + 21.844) * LBS_PER_KG *
       MaxDryCowCount
HerdManurePerDayHeifer15To24 =
       (((Heifer15To24AvgWeight / LBS_PER_KG) * 0.018) + 17.817) * LBS_PER_KG *
       MaxHeifer15To24Count
HerdManurePerDayHeifer7To14 =
       (((Heifer7To14AvgWeight / LBS_PER_KG) * 0.018) + 17.817) * LBS_PER_KG *
       MaxHeifer7To14Count
HerdManurePerDayCalf4To6 =
       MaxCalf4To6Count * MANURE_EXCRETION_WEIGHT.CALF
HerdManurePerDayCalfTo3 =
       MaxCalfTo3Count * MANURE_EXCRETION_WEIGHT.CALF
```

Nitrogen Generated

```
' Nitrogen excreted per day per maturity stage expressed in pounds.
HerdNPerDayMilkCow =
       MaxMilkCowCount * ((milk * 4.204) + 283.3) * KG_PER_G * LBS_PER_KG
HerdNPerDayDryCow = MaxDryCowCount * NITROGEN_EXCRETION.DRY_COW
HerdNPerDayHeifer15To24 =
       MaxHeifer15To24Count * NITROGEN_EXCRETION.HEIFER
HerdNPerDayHeifer7To14 =
       MaxHeifer7To14Count * NITROGEN_EXCRETION.HEIFER
HerdNPerDayCalf4To6 =
       MaxCalf4To6Count * NITROGEN_EXCRETION.CALF
HerdNPerDayCalfTo3 =
       MaxCalfTo3Count * NITROGEN_EXCRETION.CALF
```

Phosphorus Generated

```
' Phosphorus excreted per day per maturity stage expressed in pounds.
HerdPPerDayMilkCow =MaxMilkCowCount *
       ((milk * 0.773) + 46.015) * KG_PER_G * LBS_PER_KG
HerdPPerDayDryCow =
       MaxDryCowCount * PHOSPHORUS_EXCRETION.DRY_COW
HerdPPerDayHeifer15To24 =
       MaxHeifer15To24Count * PHOSPHORUS_EXCRETION.HEIFER
HerdPPerDayHeifer7To14 =
       MaxHeifer7To14Count * PHOSPHORUS_EXCRETION.HEIFER
HerdPPerDayCalf4To6 = MaxCalf4To6Count * PHOSPHORUS_EXCRETION.CALF
HerdPPerDayCalfTo3 = MaxCalfTo3Count * PHOSPHORUS_EXCRETION.CALF
```

Potassium Generated

```
' Potassium excreted per day per maturity stage expressed in pounds.
HerdKPerDayMilkCow =
       MaxMilkCowCount * ((milk * 1.800) + 31.154) * KG_PER_G * LBS_PER_KG
```

```
HerdKPerDayDryCow =
       MaxMilkCowCount * POTASSIUM_EXCRETION.DRY_COW
```

Salt Generated

```
' Salt excreted per day per maturity stage expressed in pounds.
HerdSaltPerDayMilkCow =
       MaxMilkCowCount * INORGANIC_SALT_EXCRETION.MILK_COW
HerdSaltPerDayDryCow =
       MaxDryCowCount * INORGANIC_SALT_EXCRETION.DRY_COW
```

Manure Totals

```
' The number of days in the reporting period.
ReportingPeriodDays = ReportingEndDate - ReportingStartDate + 1

' Manure herd totals per day expressed in pounds.
HerdManurePerDayTotal =
       HerdManurePerDayMilkCow + HerdManurePerDayDryCow + HerdManurePerDayHeifer15To24
       + HerdManurePerDayHeifer7To14 + HerdManurePerDayCalf4To6 +
       HerdManurePerDayCalfTo3

' Manure herd totals per reporting period expressed in tons.
HerdManurePerPeriodTotal =
       (HerdManurePerDayTotal * ReportingPeriodDays) / LBS_PER_TON
```

Nutrient Totals

```
' Nutrient herd totals per day expressed in pounds.
HerdNPerDayTotal =
       HerdNPerDayMilkCow + HerdNPerDayDryCow + HerdNPerDayHeifer15To24 +
       HerdNPerDayHeifer7To14 + HerdNPerDayCalf4To6 + HerdNPerDayCalfTo3
HerdPPerDayTotal =
       HerdPPerDayMilkCow + HerdPPerDayDryCow + HerdPPerDayHeifer15To24 +
       HerdPPerDayHeifer7To14 + HerdPPerDayCalf4To6 + HerdPPerDayCalfTo3
HerdKPerDayTotal = HerdKPerDayMilkCow + HerdKPerDayDryCow
HerdSaltPerDayTotal = HerdSaltPerDayMilkCow + HerdSaltPerDayDryCow

' Nutrient herd totals per reporting period expressed in pounds.
HerdNPerPeriodTotal = HerdNPerDayTotal * ReportingPeriodDays
HerdPPerPeriodTotal = HerdPPerDayTotal * ReportingPeriodDays
HerdKPerPeriodTotal = HerdKPerDayTotal * ReportingPeriodDays
HerdSaltPerPeriodTotal = HerdSaltPerDayTotal * ReportingPeriodDays

' Apply loss to atmosphere for the annual report's reporting period.
HerdNAfterAmmoniaLoss = HerdNPerPeriodTotal * RESIDUAL_N_AFTER_LOSS
```

Process Wastewater; Generated, Nitrogen, Phosphorus, Potassium and Salt Content Computations

Process Wastewater (PWW) volume and nutrient content as nitrogen, phosphorus, potassium, and salt generated is estimated by summing all reported wastewater applied to land application areas with all wastewater exported, and subtracting all wastewater imported (consistent with the method used in the 2008 Annual Report spreadsheet approved by the Central Valley Regional Water Quality Control Board). Process Wastewater (PWW) volume and nutrient content (nitrogen, phosphorus, potassium, and salt) as residual in storage and other loss (evaporation, infiltration, etc.) estimates are excluded at this time.

Process Wastewater Generated

```
' Compute wastewater generated in gals.  Uses accumulated values of
' wastewater applied, imported, and exported.
WastewaterGenerated =
       WastewaterApplied + WastewaterExported - WastewaterImported
```

Process Wastewater Content

```
' Compute nutrients in wastewater generated in lbs.
WastewaterNitrogen =
       wastewater.NitrogenApplied + wastewater.NitrogenExported -
       wastewater.NitrogenImported
WastewaterPhosphorus =
       wastewater.PhosphorusApplied + wastewater.PhosphorusExported -
       wastewater.PhosphorusImported
WastewaterPotassium =
       wastewater.PotassiumApplied + wastewater.PotassiumExported -
       wastewater.PotassiumImported
WastewaterSalt =
       wastewater.SaltApplied + wastewater.SaltExported - wastewater.SaltImported
```

Discharges and Discharge Summary

Dairy owners and operators must indicate whether any discharges or releases of waste to land areas (land application areas or otherwise) or surface water occurred within the reporting period. Reporting requirements vary depending on the type of discharge including, but not limited to; discharge types, sources, dates, times, locations, durations, methods of measuring discharge volumes and flows, rationale for sampling locations, and discharge map references.

Nutrient Management Plan Statements

Dairy owners and operators must acknowledge, record, and report the development, certification, and status of the dairy facility's Nutrient Management Plan (NMP) in each reporting period (annually).

Fields

Dairy owners and operators must record and report all land application area fields, including land under control of the milk cow dairy owner or operator, whether it is owned, rented, or leased, to which manure or process wastewater from the production area is or may be applied for nutrient recycling. Dairy owners and operators must record and report field common names or codes, assessor parcel numbers, total acres under the control of the facility owner/operator, and cropable acres. Multiple fields can be listed for any single parcel, and any single field may span across numerous parcels through linkage tools provided.

Crops

Dairy owners and operators must record all crops planted on land application area fields receiving manure or process wastewater from the dairy facility that will be harvested during the reporting period, whether or not the crop was planted prior to this period. It is not necessary to include crops that do not

receive nutrient applications derived from the dairy facility. Dairy owners and operators must record and report crop types, acres planted, plant date, anticipated harvest yield (tons/acre), and harvest content (lbs/acre). A crop nutrient content help table is available as a link. For validation purposes all crops entered must have at least one nutrient application event (not necessarily derived from the production area).

Sampling, Analyses, and Reporting:

Sample types listed below correspond with RB5GO requirements. Review the Monitoring and Reporting section of the RB5GO for specific information regarding sampling and analyses requirements. In accordance with the General Order, all sampling and analysis plans must be developed and approved by a qualified nutrient specialist.

Manure Analyses

Dairy owners and operators must record and report all manure sampling events and constituent analyses results for the reporting period. Non-detects should be reported as 0 (zero). The sample description may be used to record sample characteristics (e.g., "Fresh corral scrapings - north heifer lot"). Analytical results recorded here will be made available for reference when recording land applications, imports, and exports. Analytical data may include sample and source description; material type; sample date; source of analyses (lab or other/estimated); percent moisture; laboratory reporting method (dry-weight or as-is basis); nutrient concentrations as total nitrogen, total phosphorus, total potassium, and total fixed solids (% ash); general mineral concentrations as percent calcium, magnesium, sodium, bicarbonate, carbonate, sulfate, and chloride content; and detection limits. A conversion utility is available for common units of mass, volume, volumetric discharge, dry matter to/from as-is, laboratory values/units, and soil nutrient/soil slice equivalents.

Process Wastewater Analyses

Dairy owners and operators must record and report all process wastewater sampling events and constituent analyses results for the reporting period. Non-detects should be reported as 0 (zero). The sample description may be used to record sample characteristics (e.g., "GRP Labs ID#2411 - Pond 1 discharge monitoring"). Analytical results recorded here will be made available for reference when recording land applications, imports, and exports. Analytical data may include sample and source description; material type; sample date; source of analyses (lab or other/estimated); laboratory reporting method (dry-weight or as-is basis); nutrient concentrations (expressed in mg/L) for total Kjeldahl-nitrogen, ammonium-nitrogen, un-ionized ammonia-nitrogen, nitrate-nitrogen, total phosphorus, and total potassium; electrical conductivity (expressed in µmhos/cm); total dissolved solids (expressed in mg/L); general mineral concentrations (expressed in mg/L) for calcium, magnesium, sodium, bicarbonate, carbonate, sulfate, and chloride content; pH; and detection limits. A conversion utility is available for common units of mass, volume, volumetric discharge, dry matter to/from as-is, laboratory values/units, and soil nutrient/soil slice equivalents.

Fresh Water Irrigation Sources, Subsurface (Tile) Drainage Systems, and Analyses

Dairy owners and operators must record and report all irrigation water sources (groundwater or surface water) used to irrigate land application areas within the reporting period (e.g., "Canal lateral 7" or "Well #3"). Irrigation sources recorded here will be made available for use when recording land applications. Dairy owners and operators must record and report all irrigation water samples and constituents analyzed for the reporting period. Non-detects should be reported as 0 (zero). The description may be used to record sample characteristics (e.g., "Fresh water used to mix pond solids"). Analytical results recorded here will be made available for reference when recording land applications. Users must select an irrigation water source; enter a sample description; sample date; source of analyses (lab or other/estimated); nutrient concentrations (expressed in mg/L) for total nitrogen, ammonium-nitrogen, and nitrate-nitrogen; electrical conductivity (expressed in µmhos/cm); total dissolved solids (expressed in mg/L); general mineral concentrations (expressed in mg/L) for calcium, magnesium, sodium, bicarbonate, carbonate, sulfate, and chloride content; and detection limits. A conversion utility is available for common units of mass, volume, volumetric discharge, dry matter to/from as-is, laboratory values/units, and soil nutrient/soil slice equivalents.

Soil Analyses

Dairy owners and operators must record and report all soil sampling events and constituent analyses results for the reporting period. Non-detects should be reported as 0 (zero). The description may be used to record the sampling interval (e.g., "Composite from 1-2 feet bgs"). Analytical results recorded here will be made available for reference when recording land applications. Data entry may include a field selection; sample and source description; sample date, source of analyses (lab or other/estimated); nutrient concentrations (expressed in mg/kg) for nitrate-nitrogen, total phosphorus, soluble phosphorus, and potassium; electrical conductivity (expressed as µmhos/cm); organic matter content (expressed as percent); and detection limits. A conversion utility is available for common units of mass, volume, volumetric discharge, dry matter to/from as-is, laboratory values/units, and soil nutrient/soil slice equivalents.

Plant Tissue Analyses

Dairy owners and operators must record and report all plant tissue sampling events and constituent analyses results for the reporting period. Non-detects should be reported as 0 (zero). The description may be used to record the sample characteristics (e.g., "Composite from Field #12–Boot Stage"). Analytical results recorded here will be made available for reference when recording crop harvests events. Data entry may include a field and planting selection; sample and source description; sample date; laboratory reporting method (lab or other estimated); percent moisture; nutrient concentrations (expressed in mg/kg) for total nitrogen, total phosphorus, and total potassium; total fixed solids (% ash); and detection limits.

Nutrient Imports

Dairy owners and operators must record and report all nutrient imports and specific content for the reporting period. Non-detects should be reported as 0 (zero). The description may be used to record the nutrient material type (e.g., "Granular Fertilizer 15-15-15"). Constituent content for a selected import will be made available to help populate nutrient content values on subsequent user screens. Review the Monitoring and Reporting section of the RB5GO for specific information regarding sampling and analyses requirements. Data entry may include a description of the import; import date; material type (dry manure, process wastewater, or commercial fertilizer); amount imported (tons or gallons); nutrient concentrations (expressed as percent) for total nitrogen, total phosphorus, potassium, and salt. A conversion utility is available for common units of mass, volume, volumetric discharge, dry matter to/from as-is, laboratory values/units, and soil nutrient/soil slice equivalents. Total tons of solids and gallons of liquids, the pounds of nitrogen, phosphorus, potassium, and salt content imported will be estimated and displayed.

Exports, Haulers, Recipients and Destinations

Dairy owners and operators must record and report all nutrient export haulers, recipients, and destinations used within the reporting period. A Manure/Process Wastewater Tracking Manifest is required in accordance with the RB5GO for all manure and/or process wastewater exported from the dairy facility. The software allows for the required manure manifesting data entered to be used to complete (auto-populate) manifesting forms online, printed individually for signature and the stored data to be used later to report export activities and display relevant nutrient content. Users may also print out blank manure tracking manifest forms to be completed by hand.

Users can enter hauler and destination information once, and later select the hauler and or recipient for subsequent activities for manure and process wastewater exports auto-populating the manifest forms. A destination for all manure and or process wastewater exports is required, and may be a street address, street name with nearest cross street, or parcel number. Export reporting requirements will vary depending on the material types. Existing analyses or constituent compositions recorded for selected material types for export will be automatically listed and available for selection by the user to help populate nutrient content values for exported materials. Nutrient content and mass or volume will be utilized to estimate and report nutrient exports.

Manure and Process Wastewater; Transferred, Exported, Imported, Nitrogen, Phosphorus, Potassium, and Salt Computations

Converting a solid amount to pounds

```
' Calculate the amount of manure exported in tons and pounds.  Hauled amount is in
' tons or cu yd.  Density is in lbs/cu ft.
(When amount is expressed in cubic yards)
tons = amount * CUFT_PER_CUYD * density / LBS_PER_TON
(When amount is expressed in tons)
tons = amount
pounds = tons * LBS_PER_TON
```

Compute dry weight from as-is weight.

```
' Compute dry weight of the material.  Moisture content is in % by weight.
dryWeight = weight * (1.0 - moisture)
```

Computing pounds of nutrient in a volume as gallons

```
' Computes the pounds of nutrient in a liquid volume.  Concentration in mg/L or
' percent by weight.
(When concentration is in mg/L)
pounds = concentration * MGL_TO_LBSGAL * volume
(When concentration is in %)
pounds = concentration * LBS_PER_GAL_WATER * volume
```

Computing salt from Electrical Conductivity (EC)

```
' Compute total dissolved solids in mg/L then ratio.  EC is in µmhos/cm.
tds = conductivity * EC_TO_TDS
tdsRatio = tds * KG_PER_MG

' Compute pounds of salt.  Volume is in gallons.
salt = tdsRatio * (volume * LBS_PER_GAL_WATER)
```

Computing salt from Total Dissolved Solids (TDS)

```
' Convert the TDS to TDS ratio by weight then compute pounds of salt.  TDS is in mg/L,
' volume is in gallons.
salt = (tds * KG_PER_MG / KG_PER_L_WATER) *
       (volume * LBS_PER_GAL_WATER)
```

Computing salt from Total Fixed Solids (TFS)

```
' Fixed solids is always in % by dry weight.  Should be used to calculate salt, if
' available.  Result is salt in lbs.
salt = dryPounds * fixedSolids
```

Single solid import, dry-weight analysis

```
' Compute nutrient amounts in lbs.  Nutrient contents are in mg/kg by dry weight.
NitrogenImported = dryPounds * (NitrogenContent * KG_PER_MG)
PhosphorusImported = dryPounds * (PhosphorusContent * KG_PER_MG)
PotassiumImported = dryPounds * (PotassiumContent * KG_PER_MG)
(If TFS is available)
SaltImported = dryPounds * FixedSolids
(If TFS is not available)
SaltImported = dryPounds * (SaltContent * KG_PER_MG)
```

Single solid import, as-is analysis

```
' Compute nutrient amounts in lbs.  Nutrient contents are in mg/kg by wet weight.
NitrogenImported = pounds * (NitrogenContent * KG_PER_MG)
PhosphorusImported = pounds * (PhosphorusContent * KG_PER_MG)
PotassiumImported = pounds * (PotassiumContent * KG_PER_MG)
(If TFS is available, which is always in dry weight)
SaltImported = dryPounds * FixedSolids
(If TFS is not available)
SaltImported = pounds * (SaltContent * KG_PER_MG)
```

Single liquid export

```
' Calculate the nutrients exported, in pounds.  The hauled amount is in gals and
' the concentration is in mg/L.
NitrogenExported = (KjeldahlNitrogenContent + NitrateNitrogenContent) * MGL_TO_LBSGAL
       * ImportAmount
PhosphorusExported = PhosphorusContent * MGL_TO_LBSGAL * ImportAmount
PotassiumExported = PotassiumContent * MGL_TO_LBSGAL * ImportAmount
(If TDS is available, see above calculation for salt from TDS; otherwise see above calculation
for salt from EC)
SaltExported = saltPounds
```

Summary of accumulations

The above are accumulated into totals. Liquid imports and exports accumulate into total gallons; solid imports and exports accumulate into total tons. Both liquids and solids accumulate into totalized N, P, K, and salt. In addition, the same values are accumulated into subtotals by material type (e.g., solid manure, process wastewater, commercial/other).

Land Application Events and Harvest:

Nutrient application/fertilization recommendations may vary significantly among analytical laboratories and nutrient specialists because of different analytical methods, yield response models, yield predictions, expected/planned precipitation/irrigation, and nutrient use efficiency. In accordance with the RB5GO all nutrient budgets must be developed and approved by a qualified nutrient specialist and include a method and basis for nutrient applications.

Three standalone detailed nutrient application planning tools associated with the NMP and ANATR modules are available as a link (see the “Links” application page, under the “Tools” header). These tools are provided to assist producers with event specific planning for dry manure, liquid manure (water-run/irrigation), and manure liquid/sludge (not water-run) applications at agronomic rates and times. It is important to note that manure and process waste water nutrient content is highly variable and rarely in proportions that match crop needs (crop nitrogen uptake often less than potassium and phosphorus uptake, etc.). For this reason, actual laboratory data should be entered for nitrogen, phosphorus, and potassium content to better understand and minimize the potential over application of one or more specific nutrient. The three nutrient application planning tools allow for empirical and metric unit entry and are designed to rapidly convert targeted applications to a nitrogen, phosphorus, or potassium basis displaying total and available nutrients on a pounds per acre basis. Nutrient availability (%) should include mineralization expectations. Liquid nutrient application tools estimate volumetric discharges in gallons, gallons per minute (for flow meters), and acre-inches. Dry manure nutrient application tools estimate broadcast rates as tons or yards per acre (though the ANATR module no longer accepts land application inputs in yards per acre). For nutrients applied by truck or trailer loads, a scale weight is advised to reduce errors often associated with volumes expressed in cubic yards. These tools should be used to refine nutrient content entries found in the Nutrient Application screens.

The user can track nutrients applied to crops and fields-based crop nutrient requirements and patterns, seasonal and climatic conditions, the use and timing of irrigation water and nutrient application restrictions in accordance with Attachment C, Technical Standards Section V., A-D of the Waste

Discharge Requirements General Order Number R5-2007-0035 (RB5GO). Total nitrogen applications, crop uptake, and phosphorus accumulation in soils are focal points of the General Order. Except under very specific conditions, application rates on the individual crop level shall not result in total nitrogen applied to land application areas exceeding 1.4 times the nitrogen that will be removed from the field in the harvested portion of the crop. See Attachment C, Technical Standards Section V., A-D. of the General Order for detailed information on nutrient budgets related to nitrogen, phosphorus, potassium, and salt. Owners and Operators must record nutrient application events as they occur to monitor nutrient budgets and gauge crop requirements as the crop matures. This nutrient application tracking tool allows the grower to record all land application events and nutrient sources utilized prior to and throughout the growing season. A land application event records the application date, method, and the weather conditions only. Land application methods include no till, plow/disc, broadcast/incorporate, shank, injection, sweep, banding, side-dress, surface and subsurface irrigation, towed tank or hose, or other methods manually entered/selected by the user. The nutrient contents associated with the application event are recorded using nutrient sources (an event may contain multiple sources). Nutrient sources are limited to five primary source types; Existing Soil Nutrient Content, Plow-down Credit, Commercial Fertilizer or Other Sources, Dry Manure, Process Wastewater, and Irrigation Water.

Existing Soil Nutrient Content:

The starting point for most land application area nutrient budgeting is soil nutrient content required for germination through harvest. Soil analyses reports are critical to set reasonable application targets for nutrient application rates. Nutrient planning specialists may recommend soil sampling before or after pre-irrigation where appropriate. A nutrient source description may be used to record the sampling interval or other relevant information (e.g., "Post irrigation"). Existing soil nutrient content should only be used to record the content of the soil following the last harvest on the field, and is applied to the crop nutrient balance. Multiple soil content entries per crop will accumulate as nutrient contributions and are not recommended. Nutrient contents recorded are expressed in lbs/acre for Nitrate-nitrogen, Total Phosphorus, Potassium, and Salt which rely on nutrient concentrations and appropriate soil column heights (thickness) most often determined by the grower and a certified agronomist/nutrient management specialist. Evaluating soil nutrient analytical results often requires extrapolation to nutrient content into soil acre-slice equivalents (averaging 2 million pounds of soil per acre in a 6 and 2/3 inch thickness). Some soil analyses reports express nutrient content in elemental form (Potassium/K, Phosphorus/P) rather than oxide form (K_2O/Potash, P_2O_5/Ortho-phosphate). Soil phosphorus analytical results are often reported as extracted/soluble phosphorus. A conversion utility is available as a link to assist in converting soil nutrient analytical data from parts per million (ppm or mg/Kg) or EC (µmhos/cm) into pounds per acre, and to/from elemental and oxide forms. If the laboratory provided nutrient values in lbs/acre, the user may enter the values without conversion. The ANATR tool calculates only one foot intervals (0-1, 1-2, and 2-3 ft bgs); for intervals other than one foot increments, use the Conversion Utility link to obtain lbs/acre from a single thickness. Soil nutrient contents are summed as total nitrogen, phosphorus, potassium, and salt for each field and crop in the rotation on a pounds per acre basis.

Plow-down Credit:

Legumes (e.g., alfalfa.) and other crop residues can contribute nutrients to subsequent crops. A nutrient source description may be used to record source characteristics or other relevant information (e.g., "4th year alfalfa – sparse"). Users select or enter a plow-down source and an application method, then enter plow down/legume nutrient credit from the previous crop (not normal crop residue) in pounds per acre. Plow-down credit contents are summed as total nitrogen, total phosphorus, potassium, and salt for each field and crop in the rotation on a pounds per acre basis.

Commercial Fertilizer Pre-Plant before Pre-Irrigation:

Commercial fertilizers and other nutrient sources (other than manure and process wastewater) are at times applied prior to or after pre-irrigation events, as starter fertilizers applied at the time crops are planted, and as a side-dress applications to crops during the growing season. Commercial fertilizer nutrient compositions are found on product labels (dry and liquid forms) and are available from the supplier. Read, understand, and carefully follow fertilizer labels. A commercial fertilizer product label posted on a 50 pound bag of granular commercial fertilizer as 15-15-15 can be interpreted as 15% nitrogen (N), 15% phosphorus (P), and 15% potassium (K) indicating the bag contains 7.5 pounds of nitrogen, 7.5 pounds of phosphorus, and 7.5 pounds of potassium (15% of 50 is 7.5) or 22.5 pounds of nutrients as N, P, and K combined. A nutrient source description may be used to record source characteristics or other relevant information (e.g., "UN-32 / gravity drip"). Phosphorus content is often expressed as ortho-phosphate (P_2O_5) and potassium content as potash (K_2O). A conversion utility is available as a link to assist in converting nutrient analytical data to/from parts per million (ppm, mg/Kg or mg/L) into percent (%), and to/from elemental and oxide forms. Commercial fertilizer and other nutrient source applications are summed as total nitrogen, total phosphorus and potassium for each field and crop in the rotation on a pounds per acre basis.

Dry Manure Applications:

Manure applications must be recorded in tons. A nutrient source description may be used to record source characteristics or other relevant information (e.g., "Fresh corral scrapings - north heifer lot"). Users select a material type from five dry manure types; Separator Solids, Scraped Material, Corral Solids, Bedding, or Compost. The user enters mass expressed in tons and the moisture content expressed in %. The laboratory reporting method is selected as a dry weight basis or as-is basis. Nutrient content is entered for Total Nitrogen, Total Phosphorus, Potassium and Salt expressed in %. Nutrient availability should include mineralization expectations. A conversion utility is available as a link to assist in converting manure nutrient analytical data from parts per million (ppm or mg/Kg) into percent (%), and to/from elemental and oxide forms. Dry manure applications are summed as total nitrogen, phosphorus, potassium, and salt for each field and crop in the rotation on a pounds per acre basis.

Process Wastewater Applications:

Process wastewater contributions are based on total volume applied. The description may be used to record source characteristics (e.g., "Pond 1 - from flush pump"). Users must select a material type

(either process wastewater or process wastewater sludge) and enter the amount applied in gallons; the Total Kjeldahl Nitrogen, Ammonium Nitrogen, Nitrate Nitrogen, Total Phosphorus, and Potassium expressed in mg/L; and Electrical Conductivity expressed in µmhos/cm. A conversion utility is available as a link to derive a total volume from a discharge rate and runtime, if necessary. Process wastewater analyses recorded for the selected material type will be listed for selection to help populate the nutrient content values. Process wastewater applications are summed as total nitrogen, phosphorus, potassium, and salt for each field and crop in the rotation on a pounds per acre basis.

Irrigation/Fresh Water Applications:

Users enter and describe all irrigation water supplies for potential application to all land application areas to estimate potential nutrient contributions to land application areas from fresh water sources (surface or groundwater). Irrigation water contributions are based on total volume and concentrations applied. The irrigation water source must be selected from a list of previously defined sources by the user. Users must enter the amount applied in gallons, the Total Nitrogen expressed in mg/L, and Electrical Conductivity expressed in µmhos/cm. A conversion utility is available as a link to derive a total volume from a discharge rate and runtime, if necessary. Irrigation water analyses for the selected water source will be listed for selection to help populate the nutrient content values. Irrigation water applications are summed as total nitrogen and salt for each field and crop in the rotation on a pounds per acre basis.

Harvest Events

Users must enter all crops harvested during the reporting period that received manure from the dairy facility, whether or not the crop was planted prior to this period. Users select a field and crop planted, enter and record the harvest date; harvest yield; mass expressed in tons; and the moisture content expressed in %. The laboratory reporting method is selected as a dry weight basis or as-is basis. Nutrient content is entered for Total Nitrogen, Total Phosphorus, Potassium and Salt expressed in %. Nutrient availability should include mineralization expectations.

Nutrient Contributions and Crop Uptake Summary:

All nutrients applied to land application areas as existing soil nutrient content, plow-down legume and/or crop residue credit, dry manure, non-irrigation (not water run) liquid nutrients, commercial fertilizer pre-plant before and after pre-irrigations (includes fresh water nutrient contributions if any), starter fertilizers at planting, in-season fertilizer side dress, nutrient sources other than manure or process wastewater, pre-irrigations prior to planting (includes fresh water nutrient contributions if any, with or without commercial fertilizer or process waste water applications), in-season irrigations (includes fresh water nutrient contributions only, if any), in-season irrigations (includes fresh water nutrient contributions if any, with or without commercial fertilizer or process waste water applications), and atmospheric nitrogen deposition (14 pounds wet and dry deposition per planted crop acre per year, reference from the University of California Committee of Experts (UCCE) report entitled Managing Dairy Manure in the Central Valley of California, University of California, Division of Agriculture and Natural Resources, Committee of Experts on Dairy Manure Management, June 2005 revision, pages 36 and 37)

are summed as total nitrogen, phosphorus, potassium, and salt. Anticipated crop harvest nutrient removal (uptake) as total nitrogen, phosphorus, potassium, and salt is estimated for all crops included in the nutrient budget on a pound per acre basis. A balance estimate is calculated for total nutrients applied and removed from each land application area (field) based upon crop harvest yields and nutrient content for each crop in a rotation on that field for the reporting year on a pound per acre basis. An estimate is also calculated regarding nutrients applied to crop removal uptake ratio for individual crops and fields on a pound per acre basis.

Manure, Process Wastewater & Other Nutrients Applied to Land Application Areas; Harvest Yield, Nutrient Balance & Ratio, Nitrogen, Phosphorus, Potassium, and Salt Content/Contributions

Converting a solid amount to pounds/acre

```
' Compute the amount in tons.
(When amount is expressed in cubic yards.  Density is in lbs/cu.ft.)
tons = AppliedAmount * CUFT_PER_CUYD * Density / LBS_PER_TON
(When amount is expressed in pounds)
tons = AppliedAmount / LBS_PER_TON
(When amount is expressed in tons)
tons = AppliedAmount

' Compute the amount in tons/acre and lbs/acre.
tonsPerAcre = tons / PlantedAcres
poundsPerAcre = tonsPerAcre * LBS_PER_TON
```

Compute dry weight from as-is weight.

```
' Compute dry weight of the material.  Moisture content is in % by weight.
dryWeight = weight * (1.0 - moisture)
```

Converting a liquid amount to gal/acre

```
' Compute the amount applied in gal/acre.  Amount is in gallons.
appliedPerAcre = AppliedAmount / PlantedAcres

' Save the applied amount in gallons.
AppliedAmount = AppliedAmount
```

Computing pounds of nutrient in a volume as gallons

```
' Computes the pounds of nutrient in a liquid volume.  Concentration in mg/L or
' percent by weight.
(When concentration is in mg/L)
pounds = concentration * MGL_TO_LBSGAL * volume
(When concentration is in %)
pounds = concentration * LBS_PER_GAL_WATER * volume
```

Computing salt from Electrical Conductivity (EC) expressed in µmhos/cm

```
' Compute total dissolved solids in mg/L then ratio.  EC is in µmhos/cm.
tds = conductivity * EC_TO_TDS
tdsRatio = tds * KG_PER_MG

' Compute pounds of salt.  Volume is in gallons.
salt = tdsRatio * (volume * LBS_PER_GAL_WATER)
```

Computing salt from Total Dissolved Solids (TDS)

```
' Convert the TDS to TDS ratio by weight then compute pounds of salt.  TDS is in mg/L,
' volume is in gallons.
salt = (tds * KG_PER_MG / KG_PER_L_WATER) *
       (volume * LBS_PER_GAL_WATER)
```

Computing salt from Total Fixed Solids (TFS)

```
' Fixed solids is always in % by dry weight.  Should be used to calculate salt, if
' available.  Result is salt in lbs.
salt = dryPounds * fixedSolids
```

Single manure nutrient source, dry-weight analysis

```
' Compute nutrient amounts in lbs/acre.  Nutrient contents are in mg/kg by dry weight.
NitrogenApplied = dryPoundsPerAcre * (NitrogenContent * KG_PER_MG)
PhosphorusApplied = dryPoundsPerAcre * (PhosphorusContent * KG_PER_MG)
PotassiumApplied = dryPoundsPerAcre * (PotassiumContent * KG_PER_MG)
(If TFS is available)
SaltApplied = dryPoundsPerAcre * FixedSolids
(If TFS is not available)
SaltApplied = dryPoundsPerAcre * (SaltContent * KG_PER_MG)
```

Single manure nutrient source, as-is analysis

```
' Compute nutrient amounts in lbs.  Nutrient contents are in mg/kg by wet weight.
NitrogenApplied = poundsPerAcre * (NitrogenContent * KG_PER_MG)
PhosphorusApplied = poundsPerAcre * (PhosphorusContent * KG_PER_MG)
PotassiumApplied = poundsPerAcre * (PotassiumContent * KG_PER_MG)
(If TFS is available, which is always in dry weight)
SaltApplied = dryPoundsPerAcre * FixedSolids
(If TFS is not available)
SaltApplied = poundsPerAcre * (SaltContent * KG_PER_MG)
```

Single irrigation water nutrient source

```
' Compute the nutrients applied in lbs/acre.  Applied amout is in gal/acre,
' content values are in mg/L.
(If Total Nitrogen is available)
NitrogenApplied = NitrogenContent * MGL_TO_LBSGAL * appliedPerAcre
(If Total Nitrogen is not available)
NitrogenApplied = (NitrateNitrogenContent + AmmoniumNitrogenContent) *
       MGL_TO_LBSGAL * appliedPerAcre
PhosphorusApplied = PhosphorusContent * MGL_TO_LBSGAL * appliedPerAcre
PotassiumApplied = PotassiumContent * MGL_TO_LBSGAL * appliedPerAcre
(If TDS is available, see above calculation for salt from TDS; otherwise see above calculation
for salt from EC; volume input to those formulas is in gal/acre)
SaltApplied = saltPoundsPerAcre
```

Single process wastewater nutrient source

```
' Compute the nutrients applied in lbs/acre.  Applied amount is in gal/acre, conent
' values are in mg/L.  Nitrogen is split into components as TKN, NO3-N, and NH4-N.
NitrogenApplied = (KjeldahlNitrogenContent + NitrateNitrogenContent) * MGL_TO_LBSGAL *
       appliedPerAcre
PhosphorusApplied = PhosphorusContent * MGL_TO_LBSGAL * appliedPerAcre
PotassiumApplied = PotassiumContent * MGL_TO_LBSGAL * appliedPerAcre
(If TDS is available, see above calculation for salt from TDS; otherwise see above calculation
for salt from EC; volume input to those formulas is in gal/acre)
SaltApplied = saltPoundsPerAcre
```

Single plowdown, soil content, or commercial/other nutrient source

These nutrient sources are all entered in lbs/acre, and there is no applied amount. No calculations are needed. Note that for soil, nitrate-nitrogen is used for the total nitrogen value and soluble phosphorus is used for the total phosphorus value.

Single harvest, dry-weight analysis

```
(See above calculation for converting harvest amount to tons/acre [comparable to crop anticipated yield], lbs/acre, and dry lbs/acre.)
HarvestYieldPerAcre = tonsPerAcre

' Compute nutrient amounts in lbs/acre.  Nutrient contents are in mg/kg by dry weight.
NitrogenHarvested = dryPoundsPerAcre * (NitrogenContent * KG_PER_MG)
PhosphorusHarvested = dryPoundsPerAcre * (PhosphorusContent * KG_PER_MG)
PotassiumHarvested = dryPoundsPerAcre * (PotassiumContent * KG_PER_MG)
(If TFS is available)
SaltHarvested = dryPoundsPerAcre * FixedSolids
(If TFS is not available)
SaltHarvested = dryPoundsPerAcre * (SaltContent * KG_PER_MG)
```

Single harvest, as-is analysis

```
(See above calculation for converting harvest amount to tons/acre [comparable to crop anticipated yield], lbs/acre, and dry lbs/acre.)
HarvestYieldPerAcre = tonsPerAcre

' Compute nutrient amounts in lbs/acre.  Nutrient contents are in mg/kg by wet weight.
NitrogenHarvested = poundsPerAcre * (NitrogenContent * KG_PER_MG)
PhosphorusHarvested = poundsPerAcre * (PhosphorusContent * KG_PER_MG)
PotassiumHarvested = poundsPerAcre * (PotassiumContent * KG_PER_MG)
(If TFS is available, which is always in dry weight)
SaltHarvested = dryPoundsPerAcre * FixedSolids
(If TFS is not available)
SaltHarvested = poundsPerAcre * (SaltContent * KG_PER_MG)
```

Summary of crop land application and harvest accumulations

The above are accumulated into crop totals. Individual land application sources are accumulated into land application event totals in lbs/acre, and into crop subtotals by material type (e.g., solid manure, process wastewater, commercial/other) in lbs/acre. Crop application totals are calculated by summing the material type subtotals. Harvest yields are accumulated in tons/acre. Harvest N, P, K, and salt content are accumulated in lbs/acre.

Crop related calculations

```
' Estimating the atmospheric nitrogen deposition value. FieldHarvestCount is number of
' harvests for all crops on the field, CropHarvestCount is number of harvests for the
' crop. Software assumes one harvest where no crop harvest is recorded for validation
' purposes.
NitrogenApplied = AND_RATE / FieldHarvestCount * CropHarvestCount

' Compute fresh water applied in acre-inches and inches.
FreshWaterAppliedAcreInches = (FreshWaterApplied / GALS_PER_ACREINCH)
FreshWaterAppliedInches = FreshWaterAppliedAcreInches / PlantedAcres
```

```
' Compute wastewater applied in acre-inches and inches.
WastewaterAppliedAcreInches = (WastewaterApplied / GALS_PER_ACREINCH)
WastewaterAppliedInches = WastewaterAppliedAcreInches / PlantedAcres

' Compute the anticipated crop harvest content in lbs/acre.  The yield is in
' tons/acre, nutrient contents are in lbs/ton of yield (as-is).
NitrogenAnticipatedHarvest =
       AnticipatedHarvestYield * AnticipatedNitrogenContent
PhosphorusAnticipatedHarvest =
       AnticipatedHarvestYield * AnticipatedPhosphorusContent
PotassiumAnticipatedHarvest =
       AnticipatedHarvestYield * AnticipatedPotassiumContent
SaltAnticipatedHarvest =
       AnticipatedHarvestYield * AnticipatedSaltContent

' Compute applied versus crop Harvest balances in lbs/acre.
NitrogenBalance = NitrogenApplied - NitrogenHarvested
PhosphorusBalance = PhosphorusApplied - PhosphorusHarvested
PotassiumBalance = PotassiumApplied - PotassiumHarvested
SaltBalance  = SaltApplied - SaltHarvested

' Compute applied to crop harvest ratios.
NitrogenRatio = NitrogenApplied / NitrogenHarvested
PhosphorusRatio = PhosphorusApplied / PhosphorusHarvested
PotassiumRatio = PotassiumApplied / PotassiumHarvested
SaltRatio = SaltApplied / SaltHarvested
```

Summary of field and annual report accumulations

The above crop subtotals are accumulated into field totals. In addition to overall totals, the annual report contains subtotals by material type (e.g., solid manure, process wastewater, commercial/other) calculated by summing the crop material type subtotals. All crop land application and harvest nutrient totals are in lbs/acre, but field and annual report totals are in total pounds. The conversion is handled by multiplying by the crop planted acres.

Annual report balance/ratio calculations

```
' Compute applied versus crop harvest balances in lbs.
NitrogenBalance = NitrogenApplied - NitrogenHarvested
PhosphorusBalance = PhosphorusApplied - PhosphorusHarvested
PotassiumBalance = PotassiumApplied - PotassiumHarvested
SaltBalance = SaltApplied - SaltHarvested

' Compute applied to crop harvest ratios.
NitrogenRatio = NitrogenApplied / NitrogenHarvested
PhosphorusRatio = PhosphorusApplied / PhosphorusHarvested
PotassiumRatio = PotassiumApplied / PotassiumHarvested
SaltRatio = SaltApplied / SaltHarvested
```

Annual Report Certifications

Users must enter, select and record the individuals certifying/signing the Annual Report. The selections made will be used to auto-populate names on statements of certification for the report output.

Notes

Users may record any notes pertinent to the review of an Annual Report, for example to justify overrides to milk cow excretion values, crop application rates of nitrogen in excess of 1.4, etc.

Constants and Conversion Factors

The following field name suffixes, constants and conversion factors may be utilized in ANATR computations:

SYMBOLS and OPERATIONS

```
Equals : =
Sum : +
Subtract : -
Multiply : *
Divide : /
Less Than : <
Greater Than : >
Function to Sum in loops (add to previous): +=
```

FIELD NAMES and SUFFIXES

```
Pounds Per Day (lbs/day) = Ppd
Cubic Feet Per Day (cf/day) = Cfpd
Cubic Feet Per Period (cf/period) = Cfpp
Gallons Per Day (gallons/day) = Gpd
Gallons Per Period (gallons/period) = Gpp
```

AREA

```
Number of square feet in an acre
    SQUARE_FEET_PER_ACRE = 43,560
```

CONCENTRATION

```
mg/L to lbs/gal
    MGL_TO_LBSGAL = 8.345e-6
mg/L to lbs/1000 gal
    MGL_TO_LBS1000GAL = 8.345e-3
Factor to convert electrical conductivity in µmhos/cm to total dissolved solids in
mg/L
(From the 2008 Annual Report spreadsheet; Reference is the "19th Edition Standard Methods for the
Examination of Water and Wastewater", Section 1030F.)
    EC_TO_TDS = 0.6
```

DENSITY

```
Water density in lbs/cu.ft.
    WATER_DENSITY = 62.4
Kg/m3 to lbs/ft3
    KGCUM_TO_LBCUFT = 0.0624279606
```

DISCHARGE RATE

```
Cubic feet per second to gallons per minute
    CFS_TO_GPM = 448.831167
```

LENGTH

```
Number of inches in a foot
    INCHES_PER_FOOT = 12
```

HERD NITROGEN EXCRETION (GENERATED)

```
Milk Cow Nitrogen Excretion, ASAE 384.2, Section 5.3.7, Equation 16, page 8

Dry Cows, Heifers, and Calves Nitrogen Excretion, ASAE 384.2, Table1.b values, Section
3, page 2

Average nitrogen excreted from dry cows in lbs/cow/day
    DRY_COW = 0.5

Average nitrogen excreted from heifers in lbs/cow/day
    HEIFER = 0.26

Average nitrogen excreted from calves in lbs/cow/day
    CALF = 0.14

Residual manure nitrogen after 30% loss to atmosphere
    RESIDUAL_N_AFTER_LOSS = 0.7
```

HERD PHOSPHORUS EXCRETION (GENERATED)

```
Milk Cow Phosphorus Excretion, ASAE 384.2, Section 5.3.10, Equation 22, page 8

Dry Cows, Heifers, and Calves Phosphorus Excretion, Table1.b values, Section 3, page 2
Average phosphorus excreted from dry cows in lbs/cow/day
    DRY_COW = 0.066

Average phosphorus excreted from heifers in lbs/cow/day
    HEIFER = 0.044

Average phosphorus excreted from heifers in lbs/cow/day
    CALF = 0.0099
```

HERD POTASSIUM EXCRETION (GENERATED)

```
Milk Cow Potassium Excretion, ASAE 384.2, Section 5.3.13, Equation 26, page 8

Dry Cows, ASAE 384.2, Table1.b values, Section 3, page 2
Average potassium excreted from dry cows in lbs/cow/day
(Potassium excretion estimates for heifers, and calves are excluded at this time.)
    DRY_COW = 0.33
```

HERD INORGANIC SALT EXCRETION (GENERATED)

```
Inorganic salt excreted in lbs/cow/day, From General Order page IS-5 (referencing the
University of California Committee of Experts (UCCE) report, June 2005 revision page
10.)

Average inorganic salt excreted from milk cows in lbs/cow/day
    MILK_COW (INORGANIC_SALT_EXCRETION) = 1.29

Average inorganic salt excreted from dry cows in lbs/cow/day
(Salt excretion estimates for heifers, and calves are excluded at this time.)
    DRY_COW (INORGANIC_SALT_EXCRETION) = 0.63
```

NUTRIENT EQUIVALENTS (ELEMENTAL AND OXIDE FORMS)

P_2O_5 (ortho-phosphate) to Phosphorus

P2O5_TO_P = 0.437

K_2O (potash) to Potassium

K2O_TO_K = 0.83

Percent nitrogen in protein

PERCENT_N_IN_PROTEIN = 0.16

ATMOSPHERIC NITROGEN DEPOSITION

Atmospheric nitrogen deposition rate in lbs/acre/year.

AND_RATE = 14

TIME

Number of minutes per hour

MINS_PER_HOUR = 60

Average number of days in a year

AVG_DAYS_PER_YEAR = 365

WEIGHT

Weight of a gallon of water in pounds

LBS_PER_GAL_WATER = 8.345

Weight of a liter of water in kilograms

KG_PER_GAL_WATER = 1.000

Number of pounds in a short ton

LBS_PER_TON = 2000

Number of pounds per kilogram

LBS_PER_KG = 2.20462262

Number kilograms per pound

KG_PER_LB = 0.45359237

Number of grams per pound

GRAMS_PER_LB = 454

Number of kilograms per gram

KG_PER_G = 0.001

Number of kilograms in a milligram

KG_PER_MG = 1e-6

VOLUME

Number of cubic feet in a gallon of water

CUBIC_FEET_PER_GALLON = 0.13368055

Number of gallons in an acre-foot

GALS_PER_ACREFOOT = 325,851

Number of gallons in a cubic foot

GALLONS_PER_CUBIC_FOOT = 7.48051945

Number of cubic feet in a cubic yard

CUFT_PER_CUYD = 27

Number of gallons in an acre-inch

GALS_PER_ACREINCH = 27154.2856